PROSPECTS AND OBJECTS OF THE INVESTIGATION OF PLANT RAW MATERIALS IN EUROPE

by

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1. INTRODUCTION.

We understand by plant raw materials all products of vegetable origin, which are used in the chemical and mechanical industries, e.g. fibres, fats and oils, essential oils, wood, cellulose, tanning substances, colouring matters, rubber and gutta percha, gums, resins and greasy substances, starch, sugar and so on; in addition, drugs, food and forage of vegetable origin.[2])

From time immemorial, man has been using various plants, which yielded him different products. As examples, we may mention flax and hemp; the oak, which yields him tanning materials in its bark; the oil plants, and cereals, which give him food and starch for technical purposes. Furthermore, there are the innumerable tropical plants, such as rubber trees (Hevea, Castilloa, Ficus and others), the cotton plant, the different oil plants; the oil palm (Elaeis), plants providing spices like cinnamon, pepper, nutmeg, etc., the sugar cane and many others. It is true to say that in times of free trade the plant materials from tropical countries tended more and more to replace local plant materials. But subsequently greater importance has been ascribed to native plants. On the continent Frederick II of Prussia opposed the importation of foreign spices, and struggled to restrict their use. Under his influence chicory obtained favour as a substitute for coffee and during his reign Marggraf and Achard began their experiments in the extraction of sugar from the sugar beet, which increased in importance only later in the time of Napoleon I during the Continental blockade. It was at this time that Boehmer[3]) published his book in Germany on native plants of economic value, which represented a compendium of all existing knowledge on materials of value contained in plants.

In the 19th Century the interest in local plant materials decreased considerably. It was the period of prosperity and of free trade, and only during the first world war did the Central Powers search for substitutes for the imported plant materials. Wild nettles were collected, interest in peat fibre (Eriophorum vaginatum) increased and

under the editorship of the well-known Professor L. Diels in Berlin-Dahlem a book on local plant materials was published.[4]) But these were only substitutes in the true sense of this word and not materials which could provide something new. When the war was over these plant materials were forgotten and people returned again to the old imported products from tropical countries. Most of these plants were cheaper and already domesticated, while the native materials mostly originate from wild plants, the domestication and improvement of which has not even begun. For instance, the wild sugar beet contains only 1.5% sugar, whilst the sugar content of the improved and cultivated sugar beet is as high as 18-25%.[5])

However, countries striving for autarky turned to the investigation of their native plants which might yield useful materials. This has happened in the USSR, which has made considerable efforts in this direction. A section for the study of plant materials has been founded in the Botanical Institute of the Academy of Sciences and the 'WIR', the Union Institute for Plant Breeding, with its multitude of sections has also investigated the plants containing raw materials. This work has brought considerable success. The new rubber plant, Taraxacum Kok-Saghyz, the rubber Dandelion, has been discovered, the oil plant, Lallemantia, has been introduced, and so on. Comprehensive studies on tanning materials, fibres, oils, essential oils, etc. have been undertaken throughout the USSR and its various Republics.[7]

In the USA on the other hand efforts have been made for the investigation and the introduction of plants providing raw materials, and the Bureau of Plant Introduction of the Department of Agriculture in Washington is specially interested in this work. A search has been made for rubber plants, which could obviate the necessity for importing rubber from tropical countries, and efforts have been made to cultivate the Guayula, the Parthenium argentatum and other rubber plants, such as the Asclepias Cornuti[8] and the Solidago-Goldenroots.[9] Under the rule of the Nazis Germany too began to study the plant raw materials which could be obtained in their country and during the second World War the question of substitute plant raw materials became more acute. Now the war is over and the reconstruction of a United Europe has started. All the countries of Europe and even of the world must mobilise their economic and agricultural potentialities and resources for the reconstruction of a strong and free world. This implies obtaining plant raw materials necessary for industry and food also from within Europe. There are a number of possibilities which have not so far been realised and we give below a survey of the problems connected with the obtainment of plant raw materials on the territory of our continent.

2. PROBLEMS CONCERNING PLANT RAW MATERIALS.

In contrast to the time of the first world war the use of substitute plant raw materials, does not now entail poor substitutes as before, but quite new materials, replacing those formerly imported from tropical countries.

a. The first problem is to discover plant raw materials suitable for this purpose. We must investigate our local vegetation and find out the plants which could be used as a basis for the breeding of cultivated plants. Our cultivated plants, such as cereals, flax, vegetables, fruit trees and innumerable others, all originate from wild plants. The wild plant has been domesticated by culture, improved, and this has often been done to such a degree, that we frequently do not know from which wild plant the cultivated one originates.[10]

When Marggraf discovered sugar in the sugar beet and Achard started with his experiments, no one considered that it would be possible to replace sugar from the sugar cane growing in tropical countries with the sugar from the sugar beet growing in Europe. Nevertheless it was possible; the wild sugar beet has been domesticated and transformed into the sugar beet with 18-25% sugar, and it has now become an accepted cultivated plant. When the Russians discovered the rubber Dandelion, the Taraxacum Kok Saghyz, in the mountains of the Tian-Schan, nobody foresaw that it would be possible to replace the rubber from the Hevea growing in tropical countries. However, it has now been proved that the quality of the rubber from the Taraxacum Kok Saghyz is good, and cultivation and selection of the plant has been started in order to improve and domesticate it.

b. However, we must not only investigate our own wild plants as to their raw material potentialities, later domesticating those found suitable; we must also attempt to find suitable foreign plants which could grow in our climate and we must introduce them. It must not be forgotten that among cultivated plants in Europe there are many which were introduced not so long ago, such as tobacco, maize, and the tomato which are all of American origin. With the exception of the cotton plant and maize, practically the whole of American agriculture is based on introduced foreign cultivated plants, which originated from wild plants. The problem of 'New cultures' is closely connected with the utilization of the plants of the whole world, with the 'mobilization', as one might say, of the plant treasures. This problem embraces the vegetation of the world and implies its rational utilization for the purposes of agriculture and industry.

c. A further problem would be to organise the quickest possible introduction and utilization of appropriate plants and the replace-

ment of less precious cultures by those which are more valuable.

d. Another problem which will be investigated is to determine if there is sufficient land in Europe for the cultivation of these new plants containing raw materials, while first priority must of course go to land for the cultivation of plants yielding food. We must also find out which land would be unsuitable for the cultivation of nutritive plants or would be only secondarily suitable for this purpose.

In Europe such land is represented by sand-dunes, infertile sandy ground, barren ground in the mountains, salty areas near the sea, bogs and marshes. We must try to utilize land of this type for the cultivation of plants containing raw materials. For instance, we must try to cultivate fibre plants on infertile sandy soils, plants giving food on the high mountains, plants containing vitamins on dunes, plants containing rubber on marshes and on the damp alluvial soils near the rivers. We can find much land which would be suitable for the cultivation of plants containing raw materials in Northern, Eastern and Southern Europe, where nature has been less influenced by man and where we could find undrained marshes and bogs, rivers which are not embanked and streams in their primitive state. Many plants grow in such more natural conditions which must be investigated as to their raw material content. And here too we can find land suitable for cultivating these plants, without diminishing the area necessary for food.[12]

North Africa too, as a country not far from Europe, is rich in land which may be utilized for the cultivation of plants giving raw materials and food. But even in Europe we can find many plants, the products of which have not yet been investigated and which could be used later for the prupose we have in mind. A great number of such plants have been found, especially for example in the USSR, where many valuable plant raw products have also been found.[13]

e. Another problem is the intensification of the culture. We have at our disposal a quite inexhaustible reservoir of plants with raw materials or valuable for food, which have only been partly investigated. We must study the possibilities of intensifying the culture of plants which have hitherto been neglected, making use of the most up-to-date agricultural technique. For example, we might cultivate quickly ripening plants which when sown in late summer, could produce a harvest of seeds containing oil the same year or not later than in early spring of the following year. We must discover forage plants, which we could mow in northern countries several times a year; we must find plants which can be grown together with other plants, as is the case, for instance, with the oil pump in Eastern Austria, which is cultivated together with maize.

f. There are also economical and social factors connected with

the problem of cultivating plants yielding valuable raw materials. It may be asked why it is necessary to collect or to cultivate plants giving raw materials or food, if we could introduce these materials or foods for little money from abroad. Furthermore, industry can also produce many of these raw materials synthetically. We need only indicate rubber or the fibres. The social aspect of the work we will undertake is a very important one. We need only consider as an example sugar beet. The countries which cultivated this plant have created—in some cases with great sacrifices—an industry based on the native sugar beet. After many initial difficulties they are producing a food necessary for the nutrition of mankind, which they could obtain as well and perhaps more cheaply from other countries. But nevertheless these countries have freed themselves from the foreign sugar industry and have founded their own. The farmer earns well with a regular income and the cultivation of sugar beet has become an indispensable part of the native agriculture. The same is the case with other plants containing raw materials, e.g. with flax and many others. We must therefore constantly bear in mind the interest of the farmer. There is another aspect also. Plants containing raw materials, which are cultivated on barren ground in the mountains can give a supplementary income to the inhabitants and contribute to their welfare. The depopulation of the high valleys in many countries is a problem of great importance, e.g. in Austria and in Switzerland. The cultivation of plants which could contribute to the improvement of the standard of life, would prove one means for overcoming this depopulation.[14]

g. Many plants contain not one raw material, but several at the same time. They may be utilized in various ways. As an example of such plants we may mention the Asclepias Cornuti, which contains oil, rubber, fibres, cellulose; syrup can be extracted, it gives honey, and the hairs of the seeds can be utilized in place of Kapok for cushions and life belts. Other plants used in various ways are maize, flax and also hemp, which give both oil and fibres; the Kok Saghyz may also be utilized in various ways, since after extracting the rubber we can use the remains for alcohol. The utilization of plant products can only be really profitable, if the plants are exploited in every possible way.

3. SOME EXAMPLES OF PLANTS CONTAINING RAW MATERIALS

a. *Fibres.* Besides the well-known fibrous plants, flax and hemp, there are many other plants containing fibres, which grow wild in Europe or are found elsewhere and could be cultivated; they could

be used for the production of string, ropes, and sacks. There is, for example, the narrow leaved reed-mace (Typha angustifolia), which provides a good fibre for these purposes and which grows on lake shores and in waterlogged areas, where it forms large communities.[16]

We can mention further some species of willows, which in many places form exceedingly large communities, as in Northern and Eastern Europe. An investigation of these willows and their communities has been made by Lossitzki[17] in White Russia. The willows contain quite a good fibre for string, ropes and sacks. They contain too, a good tanning material in their bark and finally they are used as plaiting material for baskets and basket furniture. The problem is to breed a willow which would contain all these products and properties at the same time and could be cultivated on barren ground.

Another fibre plant is the common broom (Sarothamnus Scoparius) which grows very well on sandy soils and is frequently sown as food for hares.[18] The Mediterranean broom (Spartium Junceum) is a good fibre plant too, which could be cultivated in forests together with other shrubs and trees.

b. *Cellulose.* The demand for cellulose is increasing more and more at the present time. For cellulose is used for the manufacture of paper and textiles and for many other purposes in the chemical industry. But it will not be long before the European forests will be unable to meet the demand, especially as they have suffered great damage in the countries devastated by the war. A start has, in fact, been made with the breeding of fast-growing trees, especially with species of poplars (Populus) which can provide us with cellulose. But there are other plants which contain this product in large quanties. There is the reed (Phragmites communis), which is very common in the less cultivated Eastern countries and forms enormous communities on the estuary of the Danube and other rivers and in some lakes such as the Neusiedler See in Austria. It would be necessary to investigate these communities in different lakes and rivers and to calculate the quantity of cellulose per hectare[19], which might be obtained.

But cellulose and raw material for paper can also be obtained from remnants of other plants, e.g. from fibre plants such as flax and hemp. The potato plant (both stems and leaves), tobacco and many plants used for other products, also contain cellulose[20]

c. *Oils.* Among the most important plants containing useful products are the oil plants, which contain oils for food and for technical purposes. Such plants were already cultivated in older times, such as oil-flax, oil-hemp, rape, poppy and many others. During the war, and even before, experiments were carried out with the

soya bean, but not all possibilities of growing oil plants have yet been studied. On the one hand we must discover oil plants which could grow on soils not utilized for other plants, e.g. on sandy soils or in the mountains, on the other hand we must try to find oil plants, which could yield a harvest in the same year, after the harvest of other cultivated plants.

The number of local plants which contain oil in their seeds in greater or smaller quantities, is very large. A number of them have been investigated, especially in the Soviet Union, but there are analyses from other countries too. But more analyses ought to be undertaken to find out the influence of soil, climate and so on. The following examples serve to show us the quantities of oil in some common wild plants.[21]

The common hound's-tongue (Cynoglossum officinale)—40%; Thornapple (Datura Stramonium)—12.17%; Common Henbane (Hyoscyamus niger) —35.31%; Marsh Stachys (Stachys palustris) —38.44—72%; Betony (Stachys offcinalis)—42%; Nettles (Galeopsis Tetrahit)—42—50%; Milfoil (Achillea Millefolium)—21%; Common Burdock (Arctium Lappa) —17%; Creeping Thistle (Cirsium arvense)—27.17%; Musk Thistle (Carduus nutans)—41—44%; Sentles Matricary (Matricaria inodora)—20%; Corn Sowthistle (Sonchus arvensis)—31.5%; Burweed (Xanthium Strumarium)—39—40%; Shepherd's Purse (Capsella bursa pastoris)— 17—27%; Penny Cress (Thlaspi arvense)—33%; Wild Radish (Raphanus Ehapahanistrum)—41—45%.

d. *Rubber and gutta percha.* In addition to synthetic rubber, industry also needs natural rubber in great quantities. But as the latter is imported from tropical countries an effort has been made to discover rubber contained in native plants. In the United States many investigations have been made, and in Soviet Russia also, where the Taraxacum Kok-Saghyz has been discovered. But this plant has not been domesticated, so that the quantity of rubber varies very much and the amount obtained on one hectare may be either small or large. Besides the Taraxacum Kok Saghyz there are many other rubber plants, such as the Scorzonera Tau-Saghyz, the Taraxacum hibernicum, the Parthenium argentatum, the Asclepias Cornuti (which has been also investigated in the USA) and the Golden Rod, a different species of Solidago. The latter contains rubber in its leaves, in greater or smaller quantities. This plant is a perennial one, so we only have to mow the plant in autumn and extract the rubber and do not have to destroy the whole plant, as is the case with the Taraxacum Kok Saghyz[10], which contains rubber in its roots.[22]

A product related to rubber is gutta percha, which has hitherto

been imported from tropical countries. But there are native plants containing this product, such as the Spindle Tree (Evonymus verrucosa), which is widespread in Eastern Europe.[23]

e. *Citric acid.* A tobacco cultivated in great quantities in the Soviet Union is the so-called Machorca tobacco with yellow flowers, the Nicotiana rustica, which can grow in colder climatic conditions than the true tobacco with red flowers, the Nicotiana Tacabum. Analyses made in the Soviet Union show that the leaves of this tobacco contain a great quantity of citric acid (about 8.9—14%) and that the production of this acid would be more economical if we could at the same time extract nicotine for use in protection of plants.[24]

f. *Vitamins.* Many plants contain in their fruits vitamin C and the amount of this vitamin has not yet been investigated in all plants. But we know that the Sea Buckthorn (Hippophaë rhamnoides), which grows well on the dunes near the sea, especially the Baltic and the North Sea, contains vitamin C in large quantities. It would thus be possible to extract the vitamin from a plant growing on uncultivated land.[25]

It would also be an interesting problem to investigate the vitamin content in hay in different types of meadows. The majority of meadows in Western Europe are artificial; natural and semi-natural meadows we find only in the mountains and in Eastern Europe, e.g. in the former Baltic States, in Poland and in Scandinavia. The food value of the hay depends not only on its chemical and botanical composition, but, according to many investigations, also on its vitamin content, which may depend on soil, manure, climate and the composition of the hay.

g. *Tanning materials.* Tannin of vegetable origin is a product which is of great value. We find it in the bark of oak, of spruce and of other trees, such as willows. The roots of many plants contain tanning materials, e.g. the docks (Rumex) and the Bergenia, which originates in the Altai mountains of Siberia, but is also cultivated as an ornamental plant in the gardens of Europe. In addition to tanning materials, the leaves of Bergenia contain hydrochinone and pyrogallol. A good tanning material is contained in greater quantities in the leaves of Rhus typhine (the Staghorn Sumac), which grows luxuriantly in gardens on the continent; in the species of Statice, which grows on maritime shores of Europe, e.g. in England in Southern and Eastern Europe; in Cotinus Coggygria, the Sumac, growing in Southern Europe[26], and in the Filipendula Ulmaria.

These examples show that there are many plants growing in Europe containing useful products. These plants could serve as a basis for obtaining valuable domesticated plants by means of selection which would supply many imported vegetable products and

could be cultivated on land not suitable for the culture of nutritive plants.

It is impossible to point out all the problems connected with the cultivation of plants containing useful raw materials. Coordinated researches and investigations on these products must be made not in one country alone, but in several countries having different soils and with different climatic conditions. It would be necessary also to publish regional inventories of all plants containing useful materials, e.g. in Central Europe, the Alpine countries, the Mediterranean countries, England and France. These inventories would be the basis for further investigations and for research work in the domain of plant raw materials and their utilization in the countries of Europe.

NOTES AND REFERENCES

1. The author of this paper was for many years Professor of Botany in the University of Kaunas in Lithuania, most of the references he gives are therefore about Central and Eastern Europe.
2. See REGEL, C. Pflanzen in Europa liefern Rohstoffe. Stuttgart 1945, where further references are given. Also: WIESNER, J. Die Rohstoffe des Pflanzenreiches, Leipzig 1927, 1928.
3. BOEHMER, C. R. Technische Geschichte der Pflanzen, welche bei Handwerkern, Künsten und Manufakturen bereits in Gebrauch sind oder noch gebraucht werden können. Leipzig 1794.
4. DIELS, L. Ersatzstoffe aus dem Pflanzenreich. Stuttgart 1918.
5. See REGEL, Note 2.
6. This section published the manuals: Materiae rudes plantarum I, Moskva Leningrad 1938 and II—1949 and Rastitelnoje syrje SSSR (Plant raw materials of the USSR), vol. I Moskva-Leningrad 1950. Russian.
7. See MEDWEDEW, P. F. Nowyje kultury USSR (woloknistyje). New cultures. Fibre plants. Moscow-Leningrad 1940. Russian. WULFF, E. Efirno, maslitschnyje rastenije, ich kultura i efirnyje masla (The plants with essential oils, their culture and the essential oils, I, II, III. Leningrad 1933—1936. Russian.
   SCHARAPOW, N. D. Nowyjw shiro-maslitschnyje rastenija (New fat- and oil plants). Leningrad 1939. Russian.
8. The literature on the *Guayula* is very large, see too VORONOV, G. N. American rubber plants and the possibility of their naturalisation in USSR, Bull. Appl. Botany, Genet. and Plant breeding, XXI, Nr 5, Leningrad 1929, NICOLAIEFF, V. The morphology and classification of the guayule plant. Bull. Appl. Botany, Genet., Plant breeding XXVII, Nr 2. Leningrad 1931. Russian with Engl. summary.
9. JORDANOVA, J. K. and BOGRAD, L. J. Solidago- a new rubber-bearing plant in the Soviet Union. Bull. Appl. Botan., Genet., Plant breeding. Series XI, 1 Leningrad 1936. Russian with Engl. summ. POLHAMUS, LOREN G. Rubber content of various species of Golden Rod. Journ. Agric. Research 47, Nr 3, 1933. 10. See REGEL 1945, l.c. KOMAROW, W. Proischoshdenije kulturnych rastenij. Leningrad 1931. (Origin of cultivated plants). Russian).

11. See Bosse, G. G. et Prilutzkaja, V. J. Le problème de la recherche des plantes caouchoucifères de l'USSR, Sovietskaia botanika Nr 5, 1935. Russian and the multitude of books in Russian on the rubber plants of the Soviet Union, e.g. Nitchiperowitch, A. A., Promyschlennyje kautschukonossy SSSR, Moskva 1938 (The industrial rubber plants of the Soviet Union). Russian. B. Keller, Kautschuk i Kautschukonossy, I. Moskva-Leningrad 1936. Russian.
12. See also Regel, 1945, 1 c.
13. See Wassiljew, W. F. Osnownyje puti izutschenija dikoi polewoi flory USSR. Sovietskaia botanika 1933, Nr 3—4. Russian.
14. See: Regel, C. Die wirtschaftliche Bedeutung der Österreichischen Alpen. Der Österreichische Volkswirt 32. Jahr, Nr 13. Wien 1946. Regel, C. Über die Möglichkeit des Anbaues von Rohstoffe liefernden Pflanzen im Gebirge. Der Landfreund 25. Jahrgang. Bern 1946.
15. A paper on the utilization of the plants in various ways is in preparation. On *Aselepias Cornuti* see Regel, C. Die Seidenpflanze. Schweizergarten, Bern 1946.
16. See too Regel, C. Untersuchungen on Phragmites communis und Typha angustifolia in Litauen (with the prouter) and Owschtschinnikow, B. N. Issledowanija rogoza w plawnjach r. Kubani. Materiae rudes plantarum I. Acta Bot. Acad. Scient. Series V. Moskwa-Leningrad 1938. Russian.
17. Lossitzki, K. B. Les saules de la Russie Blanche. Sovietskaia Botanika 1936, Nr 6. Russian.
18. See the different papers on this subject by F. Tobler in his journal 'Faserforschung' published in Leipzig and the book by the same author 'Deutsche Faserpflanzen und Pflanzenfasern' München, 1938.
19. See Regel, C. 1945 and Regel, note 16 l.c., Schieber, W. Neue Rohstoffquellen für Zelllose. Die Umschau 45, Nr 37, Frankfurt a.M. 1941, Wettstein, F. Die Züchtung von Birke und Pappel, Die Umschau 44, Nr 47, Frankfurt a.M. 1940 und über den gegenwartigen Stand der forstlichen Pflanzenzüchtung. Allgem. Forst.- und Jagdzeitung, 118, 1943 and Chronica Botanica IX, 1945.
20. See Regel 1945, l.c. and Schieber, 1941, l.c. Regel undertook an investigation in Lithuania on the quantity of *Evonymus* verrucosa in the forests.
21. Regel, C. In Mitteleuropa wildwachsende und angebaute Ölpflanzen. Angewandte Botanik XXII, H.6. Berlin 1940. Regel, C. Beiträge zur Kenntnis von mittel-europaischen Nutzpflanzen II. Angewandte Botanik XXIII, H.4. Berlin 1941, and Scharapow, see note 6. See too Diels 1918.
22. See too note 1 and Böhme, R. W. Anbau und Züchtung von Kautschuk- und Guttaperchapflanzen in der gemässigten Zone. Zeitschr. Pflanzenzüchtung XXII. Heft 3, 1930. Ulmann, M. Kautschukpflanzen des gemässigten Klimas. Berlin 1951.
23. Regel, C. Beiträge zur Kenntnis von Mitteleuropäischen Nutzpflanzen I. Angewandte Botanik XXIII, Heft 3, Berlin 1941 and Böhme 1940, l.c.
24. Schmuck, A. Research on the acids of tobacco. State Institute for tobacco Investigations. Bullet. Krasnodar 1929. Russian with English summary.
25. *Hippophae rhamnoides*, growing in the Alpes, contains more vitamins, than the plant growing on the sea dunes. The literature concerning vitamins is very extensive.

26. See PRAWDINE, L. F. et JAKIMOV, P. A. *Salix Caprea* comme une plante technique de valeur. Sovietskaia botanika 1940 Nr 1. Russian. *Rumex thyrsiflorus* Fingern growing abundantly in eastern Europe contains tanning materials. See a paper in Sovietskaia botanika 1941. On Bergenia see JAKIMOV: Technitscheskoje rastenije Badan (The technical plant Badan), 1927, Russian. MILBERG, C. K. and JAKIMOW, P. Biochemija Badana (The biochemistry of the Badan) in Biochemistry of the cultivated plants V. Moskow-Leningrad 1939. Russian. On *Statice* see CHERNOVA, N. M. The Kermeks of the Krimea. Bullet. Appl. Botany, Genet. Plant Breeding, X-d Series Nr 1. Leningrad 1939. Russian. On *Cotinus Coggygria* see WULFF, E. Les plantes tannantes de la Crimée.
Les éspèces du genre Rhus par préférence et leur application dans l'industrie Annales Jardin Botan. Nikita Vol. 8. Yalta 1925 Russian and YAKIMOV, P. A. and ULMANN, K. E. The Sumach and the skumpia as tanning plants. Bullet. Appl. Botanny Genet. Plant Breeding, X-d Series Nr 1. Leningrad 1933. Russian with engl. summary.